

# Visualizations, Support for Visual Thinking

Colin Ware

Data Visualization Research Lab, CCOM, UNH

The purpose of visualization is generally to allow people to make better decisions based on data through a process of *visual thinking*. The visual thinking process involves searches for patterns that represent task relevant information. Accordingly, a major challenge of visualization is discovering methods for mapping data into a visual representation so that critical patterns can be readily identified. Since some patterns are much more easily identified than others, effective approaches are likely to develop mapping algorithms guided by an understanding of human perception. A perception oriented approach can guide effective display algorithm development and help avoid ineffective visualizations that are all too often the result of both algorithm and gadget motivated research.

In addition to considering the perceptual laws of human pattern and space perception we must also consider interactive techniques and the *cost of knowledge*. This is especially important in *information visualization* but is also relevant to *scientific visualization*. The challenge will be to develop a cognitive systems approach, wherein the costs of interaction are taken into account. Certain interactive techniques can greatly increase the size of data sets that can be visualized. For example in Munzner's Constellation and our MEGraph system, interactive local searching of a graph can increase the size of graph by orders of magnitude that can be effectively used in problem solving by (Ware and Bobrow). A cognitive systems modeling approach should take into account interaction costs as well as traditional cognitive costs in designing information interfaces.

I believe that we need to take a cognitive systems approach to modeling based on simple and powerful cognitive design heuristics. For example, we (Plumlee and Ware) have been able to use a simple model of visual working memory capacity (3 visual objects) in order to determine when extra views are needed in an information display. The heuristic: extra views are needed if a visual comparison required more than 3 pieces of visual information. Design heuristics must necessarily be simple since interactive visualization designers are unlikely to make the time investment needed to apply more complex and elaborate models. Moreover complex models are incompatible with the rapid prototyping needed for effective design.

The challenge: To develop a perceptual cognitive systems approach to visualization design. To be useful, the approach must provide support for design through robust general purpose design heuristics. Research is needed on perceptually motivated rendering methods, cognitive systems design heuristics, and novel interactive display technologies.

A current barrier to solution is the academic separation of disciplines. The ideal research program should be a collaboration between computer graphics experts, perceptual psychologists, cognitive psychologists, visual graphic designers, visualization researchers, hci researchers,

statisticians, numerical analysis and application domain experts. Undergraduate and graduate programs combining these disciplines should be encouraged.